THE PHYSIOLOGY OF MASTICATION

SIM WALLACE

THE PHYSIOLOGY OF MASTICATION

AND

KINDRED STUDIES

By the same Author

THE CAUSE AND PREVENTION OF DECAY IN TEETH

PRESS OPINIONS

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THE IRREGULARITIES OF THE TEETH

WITH REFERENCE TO CAUSATION, PREVENTION, AND TREATMENT

THE PHYSIOLOGY OF MASTICATION

AND

KINDRED STUDIES

BY

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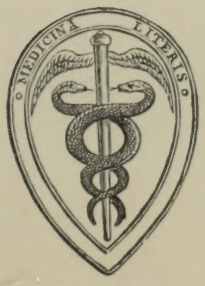

LONDON
J. & A. CHURCHILL
7 GREAT MARLBOROUGH STREET
1903

PREFACE

THIS pamphlet is published in the hope that it will help to draw attention to a generally neglected subject. The articles, though primarily addressed to the dental profession, are at least of equal importance to the medical practitioner.

J. SIM WALLACE.

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THE PHYSIOLOGY OF MASTICATION*

In the following description of the act of mastication taken from Huxley's "Elementary Physiology," there seems to be an incompleteness if not an error. It runs: "When solid food is taken into the mouth it is cut and ground by the teeth, the fragments which ooze out upon the outer side of their crowns being pushed beneath them again by the muscular contractions of the cheeks and lips; while those that escape on the inner side are thrust back by the tongue, until the whole is thoroughly rubbed down. . . . When the food is sufficiently ground, it is collected, enveloped in saliva, into a mass or bolus which rests upon the back of the tongue, and is carried backwards to the aperture which leads into the pharynx."

It will be observed that this description would lead one to think that the food is comminuted, mixed with saliva, and made into bolus form and then swallowed.

What actually takes place is very different. Firstly, however, it must be noted that certain food-stuffs which are consumed at the present day are hardly subjected to the process of mastication at all. The food is simply taken into the mouth, receives a general squash between the teeth or between

* Published originally November 1900, *British Journal of Dental Science*.

the dorsum of the tongue and the hard palate, and is then swallowed. This method of mastication—if mastication it can be called—is, as a rule, adopted for custards, fine meal porridge, soft puddings, and soft non-fibrous foods generally.

When there is a certain amount of coarse or fibrous matter in the food-stuff, then the process is essentially different, and mastication is performed in a more thorough manner. In this latter case, the food is crushed and torn between and heaped on to the masticating surfaces of the teeth by the muscular contractions of the tongue, cheeks, lips, and motions of the lower jaw. During comminution between the teeth, the juices of the food-stuffs, the saliva which becomes incorporated, and the suspended non-fibrous part, are pressed out from the fibres and gradually collect during the process on the middle of the dorsum of the tongue, which is gradually hollowed out for the reception of such food, and this part is then swallowed. The fibrous part of the food, however, is subjected again and again to the crushing and disintegration between the teeth. If any of the fibrous part passes towards the back of the dorsum of the tongue, it is arrested by the pressure of the anterior part of the tongue against the rugæ of the palate, and while the fluid and finely comminuted part gets sucked or pressed back into the hollow formed at the back of the dorsum of the tongue, the coarse and fibrous parts are thrown between the teeth and subjected again to the crushing, squeezing, and comminution. The rough surface of the tip and dorsum of the tongue and the smooth-ridged palate are especially well adapted for this separation of the food prepared for swallowing, and that which requires further mastication.

If careful note be taken of this process, therefore, it will be found that the food is not, as a rule, formed

into a bolus and then swallowed, but that the bolus is continually slipping away to the dorsum of the tongue to be swallowed till there is almost or quite no bolus left at all.

The recognition of this, which I consider the essential nature of the process of mastication, is of great importance, for as I have pointed out elsewhere,* the effect of chewing food of a more or less fibrous nature tends to dislodge the fine particles of food-stuffs which otherwise are apt to lodge between and in the crevices of the teeth, and then give rise to dental caries.

At the present day there is a positive craze for the elimination of coarse and fibrous matter from the food-stuffs, and thus to a certain extent real mastication can be but imperfectly performed, and its beneficent effects are almost wholly lost.

It is well known that the lodging of food-particles (especially carbo-hydrates) in the mouth is liable to bring about caries of the teeth, and if the chemical nature of the fibrous part of the food, even that taken from the vegetable kingdom, be taken into consideration, it will be observed to be less amylaceous or saccharine than is the non-fibrous part.

There are other ways in which the masticating of fibrous food is beneficial. Not only are the teeth kept cleaner than a tooth-brush can keep them, but the salivary and buccal secretions are more thoroughly stimulated, the deposit of tartar and the recession of the gums are prevented, and the tongue when required to perform the requisite motions during the process of thorough mastication develops more fully, and brings about a more regular set of teeth than can possibly be got if the tongue is not well developed. Finally the stomach and intestines are supplied with that more or less innutritious matter

* "The Cause and Prevention of Decay in Teeth."

which is necessary for the healthy performance of their functions.

It is, I believe, partly on account of a want of a correct knowledge of the Physiology of Mastication and its beneficent effects, together with an almost exclusive consideration of the food-stuffs from the point of view of assimilability, which leads to prescribing foods for invalids and children which are almost invariably so refined and prepared as to encourage little or no mastication.

A thorough appreciation of the process, the essential nature of which I have simply alluded to, its beneficence when well performed, and its seriously harmful results when it is not efficiently performed, would, I feel sure, work a total change in our conceptions of what are supposed to be good wholesome foods at the present day.

The beneficent results of mastication *cannot* be got by trying to go through the process if the food is not fit for mastication. It is therefore useless to tell patients that they must masticate their food without at the same time prescribing food which can be, and in fact requires to be, thoroughly masticated.

SOME EFFECTS OF THE REFINEMENT OF FOOD*

THERE are at present several different dietetic theories of the cause of the prevalence of dental caries; one element, however, is common to them all, namely, that the change brought about by modern processes for preparing and refining food is answerable for the prevalence of the disease. It is maintained by some that the removal of the husk from the grain, for example, impoverishes the amount of bone-forming salts, phosphates, &c.; by others, again, that the removal of the husk diminishes the amount the jaws require to be used and deleteriously affects the blood-supply and consequent nutrition of the teeth. By still others, the refinement of the foods is supposed to cause the food-stuffs and bacteria to be specially lodgable in the crevices of and between the teeth, &c. It is not my intention to enter into a discussion on the relative merits of the different views, suffice it here to say that if we maintain that the elimination of the coarse and fibrous elements, *e.g.*, the husks of the grain, the skins of fruit, the tough parts of meat, &c., is harmful to the teeth, we are bound to consider whether the supposed advantages gained for the stomach and economy in general by such refinement are of more importance than the deleterious effect upon the teeth.

* Paper delivered before the Odontological Society of Great Britain, June 1902.

It does seem very surprising to maintain that the refined foods which are prepared with all care should be conducive to such havoc in the teeth while that very refinement *appears* to be a necessity for the stomach. It is as if we would maintain that Nature had adapted us so that we must always exist between Scylla and Charybdis. I very frequently tell my patients that they must give up feeding their children on refined foods, and am generally met with the rejoinder that the stomach is of much more importance than the teeth, and that coarse and tough foods could not be digested by the patient, much less by children. With children's specialists, too, a like idea prevails. They appear to think that in general the feeding of children, as advocated in current text-books, is as sufficiently nearly correct as is necessary for all general purposes. This, however, I believe to be an erroneous idea.

Let us approach the subject philosophically. Firstly, let us consider the subject deductively from biological principles, and having found the general principle let us subject it to the test of facts so far as they are known and admitted.

It is a general law that animals, when subjected to any particular environment, become in the course of generations adapted to that environment or die, and that having become adapted to the environment, acquire a hereditary structure which tends to continue indefinitely till impressed forces or change of environment changes that hereditary structure. It follows that animals are adapted to that environment under which they have lived for countless generations, and are not adapted to a changed environment when such is forced upon them.

To descend now from the general principle to the case in hand. The ancestors of present-day man, savages, Simian progenitors, &c., lived a life which

necessitated their living largely on natural foods selected with an instinct which apparently showed no mean regard for their animal economy. The environment remained practically the same from one generation to another, and the hereditary structure became eminently adapted to this environment. As regards these foods, they were simply much the same as the natural foods are to-day before they are subjected to processes of elaborate refinement and cookery. The hereditary structure according to biological principles still survives, if not in its entirety yet in great part. That we are structurally unfitted to the new foods is amply manifested by the fact that about 95 per cent. of us are well supplied with carious teeth and a similar percentage troubled with chronic or occasional indigestion. I will say, at least, that carious teeth and dyspepsia are among the very commonest afflictions to which man is subject. We know that prehistoric man had relatively excellent teeth, and we know also that Nature would have made short work of him had he been crippled with dyspepsia. We know, moreover, that in their natural environment savages and anthropoids are not very subject to dyspepsia. In fact, they must maintain themselves in fairly vigorous health throughout their whole life, or succumb to their natural enemies.

Since it has been ascertained that acquired characters are not transmitted, we must conclude that civilised man should have just about as excellent a digestive apparatus as uncivilised man or his progenitors, and that decayed teeth and indigestion are practically in all cases brought about by avoidable indiscretions, especially indiscretions in diet. This, at least, is my belief, and a perusal of what follows may show the likelihood of the general truth of the assertion.

Let us consider the matter from an analysis of known facts. Food must, according to the physiologist, supply the following requirements; it must contain a certain amount of proteids, carbo-hydrates, hydrocarbons, salts and water, and, what is most important from the point of view of the present paper, it absolutely must contain a certain and considerable amount of *indigestible*, *innutritious*, and *unabsorbable* matter. This fact is very generally overlooked, and it is the origin of most of our digestive and dental troubles. Do not many of children's troubles arise from constipation and the varied decomposing products generated in the intestine from the lodgment of food? Is not the very first step in the treatment the administering of some drug which will clear out the foul mass of fæcal matter? A very general state of affairs is first a gradual onset of constipation, then a purge, and the patient goes on well again with a tendency to constipation, which must inevitably increase if a reasonable amount of unabsorbable matter is not given. Special care is taken not to give anything irritating, for if such food is given it will, of course, augment the evil effects of the fermenting mass in the intestines. But surely, this is a stupid way to go on. Would it not be much better to allow a moderate amount of inert, innutritious matter, such as cellulose, to remain in the foods? A sufficiency to stimulate the peristaltic actions of the stomach and intestines, and so induce a continuous, regular, and rhythmic performance of this natural function. It is extremely difficult for the intestine to transmit tiny quantities—a "very considerable quantity" is necessary.

"This extraordinary care" which is taken "to employ nothing in our diet but matter which has nutritive value, that is, can be absorbed into the

system, is founded upon want of knowledge of the first principles of digestion, and yet, strange to say, the mistaken, indeed mischievous, practice is supported, probably for want of thought, by many who ought to know better." *

A fact of some significance is that very many cases of chronic dyspepsia are due to want of sufficient movement of the stomach or intestines, or both. Here, again, the stimulus of a course and fibrous diet would in the early stages presumably avert the disease. I may here refer to the fact that frequently a loose use of certain words give rise to much error. Thus the word "indigestible" is frequently used as meaning taking a long time to digest or as giving rise to dyspeptic symptoms accompanied by pain. A patient may pass inert matter almost in the state in which it was swallowed, and it may then be said to be obviously indigestible, meaning "*unabsorbable.*" The patient is promptly told to avoid eating this substance again, because it is indigestible in the sense that it requires a long time to digest. Such foods are, however, *ex hypothesi* inert, they pass through the body unchanged and exert no action, or at least only that muscular activity of the intestine which is necessary to transmit them.

So far, therefore, as regards the necessary innutritious matters in the food-stuffs are concerned, the refinement does not appear to be any more beneficial from the point of view of gastric digestion than it is premised to be from the point of view of the teeth.

Now let us turn our attention more especially to the carbohydrates. Let it be remembered that the starchy matters of the food are to a considerable extent digested by the action of the ptyaline of the

* "Food and Feeding," by Sir Henry Thompson.

saliva in the mouth. Let it be remembered, too, that when the starch passes into the stomach its digestion is after a very short time completely arrested. Now, if the starchy matter is much refined and taken in a form in which it does not require to be retained in the mouth and masticated, then, of course, it is passed rapidly into the stomach and the salivary digestion is almost *nil*. The stomach is liable to be overloaded with undigested starch and the various disorders of amylaceous dyspepsia may result. If, however, the innutritious fibre, which is to a large extent cellulose, had not been removed or pulverised in the process of refinement, then the teeth would have had to perform their natural function; the food by its coarseness would have necessitated thorough trituration and insalivation; the starch would have been much more thoroughly converted; the stomach would not have been overloaded with an unnecessary amount of unconverted starch, and the innutritious cellulose would stimulate the rhythmical action of the stomach and intestine, which is frequently so sluggish.

It is somewhat curious to notice the devices which are being adopted to overcome the harmful effects of refining the carbohydrates. One error is introduced to rectify a previous error; whereas a study of natural foods and Nature's methods indicates that the first error should be corrected and the supplementary secondary errors would be superfluous. Malted foods and predigested starch are administered in the hope of rectifying matters, but whether this is really properly accomplished is, according to Aitchison Robertson,* doubly doubtful.

With regard to sugar, the effect of refinement is particularly harmful. The refinement of the foodstuffs from which sugar is obtained is carried to

* *Journal of Anatomy and Physiology*, 1898.

such an extent that instead of the succulent tuber of the beet or the fibrous sugar-cane we get the highly concentrated and crystalline product we know as sugar. Now it is known that sugar can be easily swallowed in quantity, and the result on the gastric digestion is to cause irritation and an excessive secretion of mucus in the stomach. I think, too, that this excessive secretion of mucus takes place in the mouth from like irritation. The harmful effect on both teeth and stomach is generally acknowledged. If, however, the sugar could only be got in the relatively unconcentrated form by chewing the beet or the sugar-cane, the secretion of mucus might only be beneficial in coating the innutritious cellulose and putting it in a fit state for passage along the alimentary canal. Within limits, too, the mucus probably acts as a protective coating to the teeth. Moreover, retention of sugar in the mouth in a dilute form, together with the fresh vegetable juices which accompany it in the sugar-cane, stimulates the flow of saliva and facilitates its conversion into a less irritating and more assimilable form. The fact that the eating of sugar stimulates thirst suggests the natural need for its dilution, and the fact of the secretion of mucus suggests the adaptation of the organism to cope best with this article of diet when taken in the form in which Nature presents it to us.

With regard to hydrocarbons, fortunately, when deprived of the fibrous envelope in which the fat globules are usually enclosed, that is, when refined to the extent that sugar is refined, they are too disgusting and sickening, and are consequently less apt to be harmful. Still, ways and means have been found, and muffins soaked in melted butter, or pastry of a similar constitution, are easily swallowed. Fats as foods in Nature are presented with an enveloping

membrane. They do not hinder digestion as they are thus at least partly emulsified. It is otherwise when the fat or oil is made to surround the starch and other food-stuffs, for then the fat acts as an envelope excluding the digestive juices, and so hinders digestion. Possibly, if the oils or fats which are incorporated in nuts, or fruits, or flesh were taken in a more or less natural form, more benefit would accrue to the teeth and less harm to the stomach.

With regard to proteids, they are usually eaten in a more or less natural state and the beneficial effect to the teeth is recognised, while, should the cooking not be bad, and the amount reasonably limited, the stomach is well able to derive benefit from them. The really refined proteid diet is, however, the beef essence, meat juice, extract of ox, in a teacup class of foods. They are more harmful to the digestion, for though, indeed, they are easily digested, inasmuch as they are quickly passed out of the stomach, and completely absorbed, they set up a secretion of acid and an unnatural craving for food at short intervals, which is equally harmful both to teeth and stomach.

With regard to the salts, especially the earthy phosphates which are eliminated with the refinements of foods, as, for example, those contained in the husks of grain, the want of a sufficient supply of these in the diet may possibly cause some derangement in the natural functions of the digestive organs. Possibly the beneficial results got by drinking mineral waters—natural and artificial—may indicate an incidental benefit by their general retention in the food-stuffs. The fact that a mixed diet is more beneficial than one containing almost solely proteids, carbohydrates, or hydrocarbons is recognised in our ordinary daily dietary, but I

should also insist on foods being mixed still further, inasmuch as the food ought to be partly fibrous as well as non-fibrous, as the fibrous part necessitates mastication and consequently insalivation. The mastication necessitated by the fibrous part sets free the starch so that it may be converted by the saliva, disintegrates the proteid matter, and allows of the covering of the mechanically irritant part with a coating of mucus, while the mastication stimulates the flow of lymph and prevents the harmful results—to which Dr. Harry Campbell has called attention—of the stagnation of the lymph in the neighbourhood of the muscles of mastication.

It should also be remembered that water taken *after* meals not only tends to cleanse the mouth, but when it passes into the stomach it stimulates peristalsis and helps digestion.

There are also some general effects on the stomach produced by the refinement of foods to which attention should be drawn, for example, the ease with which refined foods can be swallowed and the want of bulk composed of inert matter leads to a very general habit of over eating. The requirements of the body can be satisfied by a small amount of highly concentrated food, but if the inert and tasteless matter is absent the palate is keenly whetted, and until the stomach is moderately full more is easily eaten. If, however, a moderate amount of innutritious fibre has to be consumed, not only is the stomach gradually filled, but the amount of saliva swallowed is considerable and the digestive juices add their little to fill the stomach, and bring about a feeling of satisfaction.

No doubt coarse food, or food which contains a fair proportion of cellulose, takes longer to digest —is delayed longer in the stomach—but this is no disadvantage whatever, all that is required is

to leave longer intervals between meals. Five or six hours between ~~each~~ meals is much better than the habit, engendered by eating too quickly digestible meals, of nibbling between meals, or the taking of four, five, or even six meals a day.

There is a class of foods which are sometimes confused with those inert substances and classed roughly as indigestible. I refer to irritant or even poisonous substances, they are soluble, and may give rise to more or less violent irritation of the stomach. Many foods contain such irritants and, of course, should be avoided, especially concentrated or in excess. So, too, those foods which give rise to irritant products during the process of digestion should not be eaten. As a precaution against the formation and lodging of such substances care should be taken that sufficient inert matter is consumed to stimulate regular evacuation of the bowels.

There is another general consideration seldom thought of, that is, the strengthening of the digestive apparatus. People who have not much to do are often what may be called healthy, but those who lead an active life are stronger and healthier. So, too, people may be able to eat ordinary refined meals and do fairly well upon them, but throw a little extra strain on their digestive organs, and they break down. This, I believe, is the "normal" state with many people. Men, however, should have a much more powerful digestive apparatus than this if only it is kept regularly in vigorous activity. This may gradually be brought about by eating a less refined diet at longer intervals. The muscular powers of the stomach and intestine are as easily developed or allowed to grow flabby as are the muscles of the rest of the body. There are limits, of course, to the eating of coarse and fibrous food. There are natural guides for this

also. For example, take the tail end of a chop and masticate it more or less, then take a corresponding amount of potato, masticate still further, and it will be observed that the potato is swallowed while the too fibrous part of the chop remains; take more potato and masticate and still it will be found that the more fibrous part of the chop remains. Such fibrous parts may be avoided.

Here it should be remarked that I thoroughly appreciate the beneficial effect of the refinement of food and its preparation in a very easily digested or even predigested form in cases of debility, whether general or localised in the digestive organs. Minced meat, pounded fish, fine bread, partially converted starch, &c., are equally beneficial, both when the teeth are absent or inoperative and when the stomach is weakened by disease. So, too, milk in small quantities at frequent intervals is undoubtedly of great use in many cases of acute dyspepsia. Little good can be derived by stimulating an already over irritable stomach. Rest in bed is frequently the best possible treatment for certain debilitated conditions of the system, but vigorous exercise is much more conducive to good health with those who are not debilitated by disease. This leads me to state one reason why the craze for the refinement of foods has come about. I am firmly convinced that many specialists are largely to blame. Doctors are continually associated with the weak and diseased. Recognising the need of nutrition at the least possible expense to the economy, they naturally advise foods which will be easily and readily assimilated. They observe over and over again that when such invalids throw excessive work on their digestive organs they break down, just as many people find that when eating coarse food their teeth break and a carious cavity

shows itself. They naturally recognise the immediate cause, while forgetting that the original cause has been working, either in weakening the teeth from caries, or the stomach from want of vigorous exercise, perhaps for years. The coarse food brings about the crisis, but the refined food has insidiously performed its mischievous effects, which are bound sooner or later to result in a breakdown.

Rest is undoubtedly advisable when an organ has broken down, but by exercise alone can we expect to regain vigorous health. We must not continually advocate the diet of the sick for children and healthy adults, even if they are not particularly strong. The subject, too, is not clearly presented in medical books. Although medically qualified myself, I had, since graduating, considerable difficulty in arriving at anything like a clear understanding of the subject. We have tables of digestibility presented to us which say, for example, that boiled rice takes $1\frac{1}{2}$ hours to digest, others that it takes 3 to $3\frac{1}{2}$ hours. We read, however, that rice is largely composed of starch, and that the digestion of starch in the stomach does not take place at all, at least only to a very slight extent, and then only during the first 20 minutes or half-hour that it lodges in the stomach. This is, of course, rather confusing when one wants to arrive at a definite understanding of the subject. It might possibly be useful if, when the word "digestible" is used, it were made quite clear whether chemical digestion, or physical digestion, or absorbability was meant: so, too, when the word "indigestible" is used, it would be well to know whether the food-stuff was meant to take a considerable time to undergo chemical or physical digestion, or whether it was unabsorbable, or whether it was of such a nature that it gave rise

to gastric or intestinal trouble either from its irritant nature or from an irritant nature acquired during the process of digestion.

Then, again, if it is carefully read, it will be noticed that "bulk," "ballast," or "innutritious matter" is a necessary constituent of a healthy diet. But this subject is dealt with so cursorily that one is left almost wholly in ignorance as to what these substances are and as to the quantity required. A definite recognition of the amount of proteid, carbohydrate, fat, and water is clearly set forth as necessary for a man of such and such a weight performing no work, or moderate work, or hard work, but no recognition is taken of the quantity of innutritious matter. Again, although this innutritious matter is spoken of as inert, strictly speaking it is not so. It stimulates peristalsis, and some forms of it may stimulate peristalsis more vigorously than others, but an investigation into the nature of the different kinds of innutritious matters requires to be made. Although a return to eating the natural food-stuffs would, I have no doubt, be sufficient to bring about a healthy and vigorous digestion, yet accurate knowledge is wanted.

It is especially with regard to children's feeding that a correct knowledge of what is best is most necessary: and here I should like to make a few observations in regard to a theory which seems to me to be worthy of consideration. It is known that a knowledge of the dentition of extinct animals gives a clue to the methods of feeding of these animals, and I believe a recognition of the dentition of children forms a guide to the correct feeding of a child. I do not refer only to the fact that up to the time of cutting of the incisor teeth the diet ought to be solely the milk which Nature supplies, nor to the fact that the existence of temporary molars indicates

that food ought to be given which requires to be masticated. These facts are already recognised, at least theoretically, by many, but the perplexing period is the time between the cutting of the lower incisors and the appearance of the temporary molars. It is during this period that much difficulty is found in regulating the diet of infants, for the appearance of the incisors indicates that suckling ought to be stopped, and in fact it generally forcibly does stop this natural process. The child must be weaned. A sudden change to the foods which are procurable in a natural state would, as administered at the present day, give rise to gastric troubles. Natural foods are always accompanied with a considerable proportion of inert matter which would be apt, if not certain, to induce indigestion. Consider the instincts of the child. Its indomitable habit of gnawing all edible substances presented to it together with its inveterate habit of sucking. Add to this that it first cuts two lower incisors, then the two upper central incisors, and shortly after the two upper lateral incisors. This being completed, there is a long interval of about five or six months before the cutting of the next group of teeth, which includes the lower lateral incisors and the four first temporary molars. Now during all this long time the child possesses two lower incisors. And they are sharp. Surely all this indicates that the best way to wean a child is to give it succulent foods which it can pierce with its incisors, especially the lower ones, and suck the juices from such foods. Why should starch be so difficult for the infant to digest ? Surely it indicates that during the process of evolution the child sucked soluble matter ? To supply the carbohydrate food, the sugars, the soluble starches and the vegetable juices would be consumed, and doubtless the craving for sugar and vegetable acid indicates a beneficial

provision of Nature to put the child in fit correspondence with its natural environment. This undoubtedly would supplement the delicate morsels from the animal and vegetable kingdoms which the primitive mother could procure for her child. No doubt, too, the fresh vegetable juices exert beneficial effects, at least it is generally recognised that a good supply of these juices are necessary to prevent the occurrence of scurvy, rickets, and other diseases which are usually inflicted on infants through the agency of modern civilisation. This indicates that *children* should not get much inert and innutritious matter from about the seventh to the fourteenth month. I have knowledge of a little infant who, during this period, was given orange liths, which he relished: he chewed them so far as he could, but was always willing for the fibre to be taken from his mouth after he had extracted the juices. He opened his mouth for the purpose, and did not show much disposition to swallow the innutritious fibre, at least in quantity. And with regard to sugar-cane, which he relished even more, he chewed it with his incisors, sucked out the juices, but did not try to swallow the fibrous part.

With the advent of the temporary molars more solid food should be given, and at this period starch can be much more easily borne. By this time the salivary glands have largely developed, and the stimulus given by continual gnawing and sucking, and sugars and vegetable juices, largely promotes the growth and functional development of these glands. Next consider the shape of the molars. Is there not a large grinding surface on each? If man were a carnivore this would be hardly necessary, but being partly a vegetable feeder it is necessary for the vegetable food to be masticated, for the cellulose enveloping the starch to be crushed, and

for the starch to be at least partly digested in *the mouth*. By the time all the permanent molars are in position the child is able, within limits, to eat anything, and only a vicious civilisation is able to undermine the natural and powerful digestion which by this time ought to have been gained.

As guides in the feeding of children, the following points might be attended to :

(1) A knowledge of the natural food-stuffs which have in past ages been habitually given to children.

(2) Knowledge of the artificial foods which are generally used, together with a knowledge of their defects, physical and chemical.

(3) A recognition of the likes and dislikes of the child with regard to natural foods.

(4) To introduce only one new food-stuff into the dietary of a child at once and to make sure that this agrees with the child before making further alteration.

(5) To increase the intervals between meals according to the length of time required for digestion in the stomach ; this attention is to be regulated by previous knowledge, the appetite of the child, and the needs of civilisation, *i.e.*, regularity of meals and ultimately three meals daily.*

I need not pursue the subject further. Enough has been said to show that the teeth and the stomach require similar food, and it is only our habit of disregarding the dictates of Nature and common sense which leads to any such supposition as that the foods which are suitable for the teeth are harmful to the stomach.

* Since writing this article I have heard that a distinguished physician is investigating the food-stuffs that more primitive men and their children actually do live upon, with a view to introducing a rational diet.

THE PREVENTION OF IRREGULARITIES OF THE TEETH*

Although the working out of the theory of prevention of irregularities of the teeth naturally devolves upon us as dentists, yet in the early stages at least the carrying of the theory into practice must devolve upon the medical practitioner or those who supervise the bringing up of infants and children. The prevention of irregularities should commence indeed before the eruption of the teeth.

It is unnecessary to advocate that an infant should be breast fed; this is quite well recognised. But as it frequently happens that artificial feeding *must* be resorted to, and as it has been noticed, or at least it ought to have been noticed, that irregularities of the teeth are a frequent sequel of artificial infant feeding, it will be as well to state that, according to my views at least, artificial feeding is not the cause of the irregularities, as irregularities are not a necessary consequence of artificial feeding, nor is artificial feeding a necessary antecedent of irregularities.

The artificial feeding of infants may almost be regarded as an exact science, and it is only the want of knowledge, or the neglect of the necessary precautions, which gives rise to the harmful results

* Extract from one of a series of papers on "The Irregularities of the Teeth," *Dental Record*, February 1903.

so often observed. Under the heading "Artificial feeding perfectly safe with due care and proper knowledge," Dr. Cheadle says, "I believe that, by proper management and precautions, all difficulties of the transfer from the breast to artificial feeding may be got over with absolute safety and in all respects satisfactorily, so that the child shall escape gastric troubles and shall thrive."*

An infant is a delicate organism, and as due care and the proper knowledge are frequently wanting the infant does not thrive, but suffers from infantile dyspepsia, malnutrition and its sequelæ. Now we have already said that the irregularities of the teeth were roughly proportional to the emaciation of the child, because the tongue, which shares in the general emaciation, does not give the developmental stimulus to the growth of the jaws which it otherwise would. Unfortunately the harmful results of ill-feeding in infancy shatter the child's constitution, and it is doubtful if it often ever becomes thoroughly robust. It is somewhat strange to notice how persistently children retain their unhealthy and half-starved appearance.

The prevention of irregularities therefore commences by the carrying out, for the first year or so, of the principles of hygiene and dietetics as currently advocated.

Here I may refer to one of the bogies of superior protrusion, "the infant's comforter." I know that it is supposed to be a pernicious invention. It is no doubt an abomination unto the dentist, but mothers are well aware that it is an ever-present help in time of trouble. I doubt if there is any good evidence to show that "the comforter" is a cause of superior protrusion or any other irregularity. It is true that in the sucking of a comforter air may be sucked

* "Artificial Feeding and Food Disorders of Infants," 4th ed. p. 45.

into the stomach and give rise to some annoyance, but this might be remedied by having the part usually grasped by the lips somewhat elliptical or flattened. On the other hand, it is usually gnawed and sucked. The gnawing helps to develop the muscles of mastication and the sucking helps to develop the tongue. Now after the teeth have cut the gum and the child is beginning to be fed on pap instead of chewable food, possibly the gnawing and sucking the comforter is, under the circumstances, one of the most beneficial things the child could do as regards the development of the jaws. However, I do not wish particularly to advocate the comforter, but will simply say that something to gnaw, as, for example, a piece of soft leather, is, in my opinion, an excellent thing for an infant to exercise his jaws and teeth upon.

Gnawing and sucking is an instinct with all children, and the satisfaction of this instinct is no doubt beneficial, so that after some teeth have appeared the food should be of a consistency such that it will demand the use of the teeth. Sugar-cane is a useful adjunct in the dietary of a child, but it is unnecessary to return altogether to primitive foods. Even highly artificial productions, such as stale bread or crusts or toast, will suffice as part of the diet, but vegetable foods rich in carbohydrates should be so dry or of such a consistency that they will absolutely necessitate mastication and insalivation. The recommendation in otherwise excellent treatises of a diet consisting almost wholly of "bread well soaked" in milk and the like * shows a complete disregard not only of the physiology of mastication but also of the whole of that important part of digestion which takes place in the mouth. Meat, fish, and poultry, tender or otherwise, according

* "Food and the Principles of Dietetics." Hutchison, p. 457.

to the age and capabilities of the stomach, should be given in large pieces cut thin. Flat pieces about one inch square generally *necessitate* a certain amount of mastication. It is difficult to swallow large flat pieces of meat without mastication, but when finely minced little or no mastication is called forth. With young or delicate children the most tender meat may be given, and in order to have it specially easily digestible, yet of a consistency necessitating mastication, it may be given more or less raw. If the child tends to swallow without mastication cut the thin pieces *larger*. Only in extreme cases is the giving of raw meat juice a necessity and then it should only be a temporary expedient. The harmfulness of inefficient mastication as regards gastric digestion has long been recognised, and, curiously enough, in order to make things right, food, at least for children, is generally practically masticated before introduction into the mouth, but to my mind this only augments the cause of the evil for which it is intended to make amends. In other words, this preparation of food as exemplified, for example, in minced meat and mashed potatoes, only further induces the child never to acquire the habit of mastication.

This is not all. The physiology of digestion is not a piecemeal business. All parts of the process are intimately co-ordinated. To illustrate this fact, which physiologists have not fully appreciated until recently, we may mention that if the œsophagus of a dog is cut, and arranged in such a way that food swallowed is passed out at the cut end instead of passing into the stomach, the psychic effect caused by the mastication of the food produces a very considerable flow of gastric juice, definite in amount. The entrance of food into the stomach, too, causes a definite amount of gastric juice to be secreted. Food

introduced into the stomach unaccompanied by mastication and concomitant psychic effect only stimulates a partial secretion of the gastric juice.*

Then, too, the amount of saliva secreted has its effect on gastric digestion. Not only does it promote the digestion of starch in the early stages of its lodgment in the stomach but probably the permeation of the proteid with the alkaline saliva renders such food more subject to the ingress of the gastric juice. The saliva does not contain mucus, carbonate and phosphate of soda, &c., for idle purposes. Perhaps our semi-atrophied salivary glands may predispose to indigestion. I have heard on very good authority that the alkali in the masticated food allows the propepsin secreted by the gastric glands to permeate the food and form pepsin in the substance of the food in the nascent and therefore most active condition. However, to administer to children with teeth food which does not require mastication is to ignore a primary fundamental and important stage of digestion. This point need not be elaborated, for it is hardly necessary to insist upon the fact that good digestion waits not only on appetite but on mastication, and if we swallow food without mastication active digestion is not stimulated and the seeds are sown of indigestion, irregularities and caries of the teeth, appendicitis, &c.

I have referred to these facts because chronic indigestion with emaciation is one of the worst troubles for producing irregularities. It is even more harmful than insufficient mastication.

To recapitulate: The food of children should be of a chemical composition, such as is found in milk, and such as is advocated currently in text-books

* "The Work of the Digestive Glands." Pawlow and Thompson. Chap. iv.

dealing with this subject, but the physical characters of the solid food should diverge from that of milk in proportion to the number of teeth erupted, that is, it should be the opposite of that currently advocated. When, for example, we read "a rusk or slice of stale bread well soaked" we should read a rusk or slice of stale bread well dried or toasted.

The next factor to be considered is the prevention of mouth breathing. We have already alluded to the fact that efficient mastication tends to broaden the nasal passages, and that narrow nasal passages predispose to the blockage of the nose and the occurrence of adenoids, but the exciting cause, colds in the head, must also be counteracted, and colds when caught should be got rid of as quickly as possible, for, as has already been mentioned, the fact that the blockage of the nose arrests its development is proved. Although some fanciful theory about negative pressure has been advanced to account for this arrest of development of the nose, we may be content with the simple idea that the abeyance of its function of transmitting air is itself sufficient to arrest its development, for with each inspiration there is a stimulation of the flow of blood *when there is no obstruction.* On the other hand, the abeyance of the rhythmical stimulation of the flow of blood is amply sufficient to account for the arrested development when the passage is permanently blocked.

Printed by Ballantyne, Hanson & Co.
London & Edinburgh